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IMPORTANT FACTORS IN THE CONSTRUCTION AND MANAGEMENT OF AIR-COOLED STORAGES

(By Roy E. Marshall, Michigan Agricultural Experiment Station, East Lansing, Mich.)

It has been demonstrated that winter varieties of apples having good keeping quality may be held safely for six months in well constructed and well managed common storage houses whose cost of construction is within reach of most owners of 15 to 20 or more acres of bearing orchard. There are other advantages to owners of such storage houses such as the possibility of selling f. o. b. the farm, being able to supply local markets and truckers throughout the season, and sorting the apples just prior to marketing rather than at harvest time.

Most storage houses are costing about 30 cents per bushel with some good ones built this past year at 25 cents. This means that the grower gets satisfactory or good storage at considerably less than 10 cents per bushel for the season when all overhead and operating expenses are figured. With present building costs, I doubt the wisdom of attempting to remodel existing farm structures for storage purposes.

Principles of Air-Cooled Storage

The air-cooled storage is designed to utilize the cooler air of the day (usually at night) for lowering the temperature of the fruit. When air is warmed, it expands and becomes lighter so that air circulation is established. If we construct an insulated building with basement window-like openings in the walls at or just above the ground line and other openings or ventilating shafts or flues extending from the ceiling through the roof, conditions are established to make use of the natural circulation of air through the storage room. If the outdoor temperature is lower than that in the storage room, the warmer and lighter air of the storage room will rise and leave the room through the ventilating shafts or flues while the cooler air from the outside will enter the building through the wall openings located just above the ground line.

The rate of air movement through the storage will be controlled by the

Editor's Note—The air-cooled storage is still on trial in Maryland, due to uncertain temperatures in the fall. However, several growers have such storages and report generally good results. There are losses to be considered from ripening, rots, shriveling, and rat injury. Common storage is best adapted to the local or nearby market. This article is for general information; not to advocate that every grower build his own storage.

following factors: 1. Difference in temperature between the outdoor air and that in the storage room in contact with the fruit; 2. The size of the wall and ceiling openings designated as cold air intakes and warm air outlets; 3. The height of the storage building or more specifically the difference in elevation between the cold air intakes and the tops of the ventilating flues; 4. The velocity of the wind; 5. The location of the building, i. e. whether it is in the open or close to other buildings, and, 6. The manner in which the fruit is stacked in the storage room.

The greater the amount of air moving through the storage, the greater the amount of fruit cooling under a given set of conditions. Our investigations show that with three air changes in a loaded storage room per hour throughout the night and with a difference between the outdoor and apple temperatures of five degrees, the temperature of the fruit may be lowered approximately one degree per day. This might appear to be rather slow lowering of the temperature. If continued without interruptions, however, the temperature of the apples would be reduced from 50 to 32 degrees in three weeks. This would be very satisfactory but is far from what we may actually expect. During or shortly after harvest differences of 10 or even 15 degrees may obtain occasionally between the temperature of the stored fruit and the outdoor air and during such nights, or even days, the fruit cools two or three times as rapidly as with a five degree difference. On the other hand, there are always some nights, such as those during November this season, when the outdoor temperature is higher than that inside the storage and even though all openings are closed tightly some heat will leak into the storage to result in some warming of the fruit.

With good construction and close attention to management the temperature of the fruit should be reduced to 32 or as nearly that temperature as desired by this time of the year (December 1), and good insulation should enable one to continue at this temperature throughout the winter and early spring.

It is evident that we are confronted with temperatures from harvest to early December that are considerably higher than ideal storage temperatures and during this time some ripening takes place. No practical way has been devised to prevent a certain amount of ripening in air-cooled storages during this period. It can be prevented but the cost of prevention does not warrant the gain.

Construction of the Building

If a grower expects to maintain a temperature of 32 throughout the winter and early spring months, there is nothing to be gained by building the storage under ground or in a "bank" because the amount of insulation that must be provided to maintain proper winter temperatures in a cellar storage is as great as that required for a building entirely above ground. More than 75 per cent of our growers build above ground. There is no economic gain in placing part or all of the building below ground level though there is no serious objection to it.

There is no one best material or method of construction. No two of our storage houses are built exactly alike, yet many of them give similar results and show similar costs of construction. The building must be so constructed that freezing of fruit will not occur during the coldest winter weather that may be anticipated.

Certain building materials, however, should be avoided. The use of lumber alone is entirely too expensive. Furthermore, lumber readily absorbs moisture from the high humidity atmosphere of the storage room and this leads to warping, molding and decay. We recommend a minimum amount of exposed lumber in the storage room. Steel posts or pillars should be used rather than lumber. The construction materials should be as nearly waterproof as is practical. When building materials absorb moisture, their insulation value depreciates.

Stone is a very good conductor of heat and is therefore not regarded as a satisfactory material for wall construction. In fact, all heavy building materials like masonry and concrete would have to be 10 to 20 inches in thickness to given an insulation value equivalent to one inch of corkboard or loose or quilted fibrous materials. Mortar used in binding the units of masonry structures together conducts heat even more rapidly and mortar joints should therefore never be continuous through a wall.

When building materials absorb moisture they lose insulating value in proportion to the amount of water absorbed. The Bureau of Standards says that no commercial insulating materials are water proof. However, some materials like concrete, soft brick and soft tile absorb moisture more readily than the hard or glazed products.

Still air is the best insulation, and its insulating value, where the air space is less than one-half inch thick, seems to be in proportion to the width. For spaces wider than three-fourths inch, however, the insulation value remains practically constant regardless of width. In other words, nothing in the way of insulation is gained by making such spaces wider than three-fourths inch. Such air spaces have insulating values approximately equivalent to one-third inch of good insulating materials.

We have favored tile construction in Michigan. Such construction is economical, is fire proof, is or may be made as nearly waterproof as any building material, is rodent proof, usually provides several air spaces, and often permits the use of additional insulation in the form of granular or powdered materials. Either of two general types of tile construction may be used with apparently equal results, at similar costs, and both types give walls of similar thickness. In one case, a double hard or glazed tile wall is built, the outer unit being of eight-inch tile and the inner one of four-inch tile. The two wall units are separated by just enough space (about two inches) to permit loose packing of some granular or powdered insulating material between the two wall units. The choice of materials for the space between the walls should be based on accessibility and cost as most of them have similar insulating values. Thermophile seems to have been the one most generally used recently. For the second type of tile construction, interlocking tile are used. They are laid up in a 12-inch wall which provides for five air spaces and mortar joints broken twice. This interlocking tile is soft and a waterproof plaster or stucco should be applied to both the outside and inside surfaces. No additional insulating materials are necessary.

Experience has indicated a wall height sufficient to permit twelve feet clearance in the storage room to be the most satisfactory. We think it advisable to run the wall high enough so that the flooring over the tops of the joists is flush with the top of the wall. Otherwise some additional precautions must be taken to prevent frost entrance at the junction of the wall and ceiling.

The joists may be of wood but the ceiling underneath the joints not to be of wood or any material likely to warp. We prefer to lath and plaster under the joists and place insulating materials between the joists or over the tops of them. In the one case, thermophile, granular or dust cork, or other granular or powdered materials may be spread to a depth of about two inches on the lath and plaster between the joists. Then matched flooring may be laid over the joists. The second method consists of laying quilted fibrous materials one inch in thickness, like hair felt, over the tops of the joists and then the matched flooring.

Provision for Ventilation

There should be one 20 by 30-inch cold air intake for each 1,000 bushels or 2,500 cubic feet of storage space. They should be evenly spaced along the sides of the building, and across the ends if the building is a wide one, and should be located just above the ground line regardless of the contour of the land. These cold air intakes should have beveled frames and should be equipped with insulated doors with edges beveled to fit the frames and hinged at the top or sides. The doors may be insulated by nailing together three thicknesses of insulating boards like Celotex and then nailing matched boards on either side of the insulating boards. They may also be made box-like with a three or four-inch space between the matched outside and inside boards and the space filled with granular, powdered or quilted insulating materials. The warm air outlet or ventilating flues should extend from the ceiling of the storage room through the roof of the building ending in a sort of cupalo. The construction of the flue is usually of smooth boards placed in a vertical position. The portion of the flue or shaft above the roof should be open enough to permit a good draft and free exit of air but should be screened to prevent entrance of litter and protected against rain and snow as much as is consistent with good draft. The bottom of the shaft should be fitted with hinged or sliding insulated doors. About two square feet of the flue or shaft is necessary for each 1,000 bushels or 2,500 cubic feet of storage capacity. Thus one shaft three by four feet would be satisfactory for a 6,000 bushel storage, though with larger capacities two flues would be advisable.

Electrically propelled fans of the propellor type should be installed in the outlet or ventilating flues where there is likely to be difficulty in securing a good draft or where the cold air intakes cannot be located along both sides of the building. In the latter case the warm air outlets should be located on the sides of the building opposite the cold air intakes. Under ordinary conditions we do not recommend electric fans because of the additional cost of installation and operation. In other words, wind or natural air movement is cheaper than electricity.

A false floor two or three feet above the dirt floor of the storage is unnecessary and materially lessens the storage capacity. We recommend a dirt floor because it helps materially to supply the proper humidity in the room. A concrete runway through the middle of the building, however, may be worth installing as an aid in handling the fruit. As the fruit is stacked in the storage, timbers may be laid on the ground so as to keep the crates off the damp dirt and to permit some circulation of air under the fruit to aid in cooling.

Stacking the Fruit

The fruit is usually stacked in orchard crates. Under present conditions the investment in crates to fill a storage house amounts to about as much as the cost of constructing the storage. No other method of handling the fruit, however, has been devised which is more practical. The use of crates permits the storage of a maximum amount of fruit per unit of storage space consistent with proper cooling of the fruit. Prompt cooling can only result when ideal conditions are provided for air circulation about the fruit.

This means that the bottom tier of crates must be elevated a few inches above the dirt floor, that the top tier shall not be nearer than approximately a foot from the ceiling, that a space of at least four or five inches exist between the outer crates and the storage walls, and that the stacks be aligned in straight rows across the storage with a space of at least an inch between stacks or rows.

Fall Management

The length of the storage season for a variety depends on the promptness of cooling to approximately 32 degrees. The date at which the apples may be cooled to this temperature in any one season depends on fall management and outdoor temperatures. Proper fall management consists in opening all cold air intakes, doors and warm air outlets whenever the outdoor temperature is lower than that in the storage room and closing these openings when the outdoor temperatures rise to that obtained in the storage room. In other words; we must take advantage of any and all outdoor temperatures lower than those of the fruit in the storage room.

Apples ripen about twice as rapidly at 40 as at 32 degrees and about four times as rapidly at 50 as at 32. In other words, apples may be expected to keep twice as long at 32 as at 40 and four times as long at 32 as at 50 degrees.

The gower does not need to worry about humidity during the fall months because the frequent ventilation tends to maintain satisfactory humidities during this period. His chief concern during October and November is to reduce the temperatures of the fruit.

Winter Management

During the average season, a satisfactory storage temperature will have been reached by December. Occasional ventilation when outdoor temperatures are just above the freezing point may be necessary to maintain the low temperature. If the storage room is nearly full of fruit, there will be no danger of freezing in a well insulated storage, because a lot of heat leakage is necessary to cool the apples to the danger point. What is the danger point? It differs somewhat with varieties but if the temperature of the fruit does not go lower than 28 degrees, no freezing will result. Maintaining the storage room at 32 therefore permits a safe range of four degrees and experience has shown that the construction would have to be faulty to permit a drop of as much as four degrees in a storage filled with fruit. Why then do some growers insist on holding the fruit throughout the winter in well constructed buildings at 35 and 36? At these temperatures the storage life of the apples is shortened about 30 per cent.

Humidity is the chief concern for the grower during the winter months. The ideal relative humidity is at least 85 per cent. For common storage

management, however, there is no need of bothering with humidity testing and recording apparatus. Simply keep the humidity high enough to prevent shriveling of the apples. Shriveling or withering results from loss of moisture which results in loss of volume and after this has progressed sufficiently the skin of the fruit becomes loose and may be wrinkled by pushing the thumb firmly over the surface. Thin skinned varieties show this condition first and they should be watched carefully.

To prevent shriveling, keep the dirt floor of the storage moist or even muddy. There is no harm in even spraying the crates and fruit provided the temperature is about 32.

If the temperature is held at about 32, one need not worry about running the humidity too high. If, however, the storage is held at 35 or 36 and higher, a high humidity may result in premature decay because such temperatures are high enough to favor a slow growth of fungi and decay organisms in a moisture laden atmosphere.

JUST AMONG OURSELVES

A. F. Vierheller, Extension Horiculturist

SUMMER MEETINGS

Following a new plan, the Society held three regional summer meetings, this year rather than one central meeting. The gatherings were held near Smithsburg, Bel Air, and Easton, on July 18, 20 and 22, respectively. A short tour of a few orchards was made in the morning, arriving at a specified orchard for basket lunch. The program of speaking followed the lunch hour. The main discussion topics centered on foreign and domestic markets, and we were told about the embargo against shipment of scale infested fruit to France, and of the 2% scale tolerance allowed on export fruit to other countries. Argentina also has a regulation requiring that each individual fruit exported to that country be wrapped in paper, whether packed in box or barrel. Efforts are being made to have this restriction removed. General topics of insect control, improvement of our present fruit situation, the optimistic outlook for the fruit grower and his relations with his banker were discussed.

Among the orchards visited were those of Gardenhour Brothers, John Martin and Aaron Newcomer in the Smithsburg section; G. P. Radebaugh, Herbert Hoopes, John Haughay and C. E. Bryan in the Bel Air section; and, Otto Sanger, J. H. Wilcox and W. Earle Withgott in the Easton section. Over 200 growers enjoyed their hospitality.

We had a good time, saw fine orchards and crops, learned a lot about our industry and its problems, and met a lot of new folks. We were glad to welcome visiting growers from Pennsylvania and Virginia. You should have been there.

ORCHARD EQUIPMENT

There is a Bean Stationary Spray Plant for sale, cheap. Less than 25% of its cost. Used for one spray only. Lack of water supply is the cause of its sale. Has a 600 gallon tank, and 1700 feet of pipe.

One grower wants to buy a used grader for apples. His crop will run about 6,000 bushels. Do you have a small grader for sale? Here's your chance.

Write A. F. Vierheller, College Park, Maryland, if you are interested in buying a spray plant or selling your small grader.

* * *

ANOTHER PROBLEM

Perhaps there is a place on the market somewhere for all grades of fruit. The question is: can we afford to put poor quality fruit on the market? Is it advisable to let the motor truck carry our inferior fruit to some good market and flood out the better grades of fruit? This is being done. Florida citrus fruit growers are selling drop fruit to trucks from other states. The truckman has this stuff washed and roughly graded. It comes north in bulk loads, and the market for good fruit is seriously affected. The same thing happens with apples, but very often they are not even washed or graded.

This question is discussed in March, 1932, "Virginia Fruit" published by the Virginia State Horticultural Society, in relation to motor truck transportation. The article says in part:

". . . . Every new invention and every marked change due to evolution has brought with it new problems that must be solved by those who benefit. The same holds true with the coming of the motor truck as a means of distributing fruit and farm products, particularly apples. We bewail the fact that the country has been flooded with low grade apples from the cull piles. Just as it is human nature to try to shift a responsibility to some one else, so is the apple industry trying to hold the motor truck responsible for its own greed and inefficiency. The apple industry has quite generally failed to realize that when it sold the "cull pile" for $25.00 to $30.00 or even less that it was generating competition of the worst kind in its own markets, against its better graded fruit. Should we blame the motor truck for the folly of the industry? Are we to forego the only opportunity agriculture has had to enjoy a reasonable priced transportation in the last quarter of a century just because the industry has not yet evolved the strength of purpose to dump the culls in the ditch? Are we to forsake the first thorough distribution of apples that the industry has ever enjoyed, because in this past season all possible conditions united to favor the saving and selling of the cull piles? Is the motor truck to blame because it was loaded with culls at your orchard? The problem of keeping culls out of the market is a problem to be solved by the apple industry itself. No other interest is going to solve that problem for the industry or to protect it from its own weakness.

SAN JOSE SCALE—AGAIN

All growers who export fruit, know that the French market has been in a turmoil regarding imports of American apples, on account of San Jose scale. The following article appeared in French papers on March 4, 1932. The high-powered press agent who wrote it, stretched facts to suit his fancy, but we get some idea of the French conception of scale.

The article follows:

"OUR ORCHARD IN DANGER

A voracious insect, the San Jose Bug, discovered in Apples imported from United States

"We have been receiving for some years past large quantities of beautiful red apples from the western districts of the U. S. A. But it has now been discovered that this fine fruit contains a dangerous enemy for our orchards. The Society of Agricultures of France, who gave the alarm ten days ago, and Inspectors from the phytopathological department of the Ministry of Agriculture paid a visit to the Paris Central Markets for the purpose of examining the latest arrivals of these apples, with the result that 80% were found to contain the formidable pest. It was quickly identified by the entomologists as the tiny insect known as the San Jose Bug (aspidiotus perniciosus) and endowed with an incredible rapidity of reproduction, the progeny of one female being able to infect as many as a million and a half subjects in a year.

"It will be remembered what ravages were caused twenty years ago in Virginia and California by a parasite emanating from China and Japan, which destroyed whole orchards of apples, pears, and peaches.

"The 'San Jose Bug' attacks first of all the leaves. Armed with a powerful dart, it sucks the sap from the leaf with the result that in the height of summer, trees are reduced to their winter condition of bareness and quickly perish. The pest is combated by aspersions of paraffin and anthracene oil, but immediate danger is the period of its introduction, as in the United States. Upon contact with healthy trees, the insect attains great virulence and causes there and then tremendous havoc. This is what we have to avoid.

"The Minister of Agriculture was at once informed of the danger, and Mr. H. Decault, president of the 'Chambre d' Agriculture' of Loiret Cher, and president of the Committee of Sanitary Defence of the Assembly of the Presidents of the Chambers of Agriculture of France, solicited that investigations should be made and preventive measures adopted.

"The investigations have been made, the Minister informed of the results, and in all probability his decision will be rendered public without delay.

"The American apples, which are always well displayed, arrive packed in two different ways, sometimes in barrels, sometimes in boxes. And it should be noted that those packed in barrels are contaminated, while those packed in boxes, are immune."

The shoe dealer was hiring a clerk. "Suppose," he said, "a lady customer were to remark while you were trying to fit her, 'Don't you think one of my feet is bigger than the other?' What would you say?"

"I should say, 'On the the contrary, madam, one is smaller than the other."

"The job is yours."

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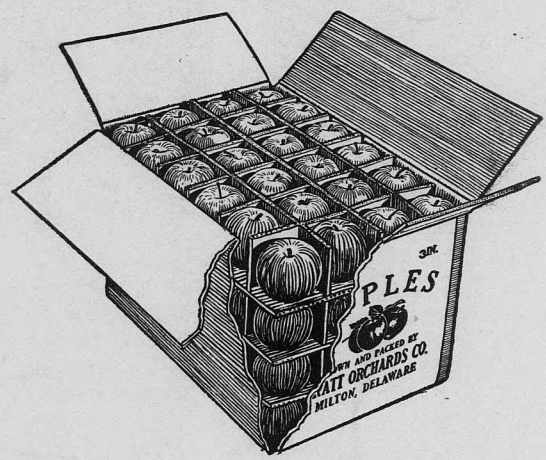

Cartons

Here is just the thing for your fancy apples. And at a price which will make you want to pack all your No. 1's in "apple-cell" cartons. The cost roughly approximates that of baskets.

Apples in "apple-cell" cartons keep perfectly, cost less to store and handle, and bring better prices on the market. We used them ourselves before we recommended them to you.

Any special cartons of any specific sizes can be supplied, but the standard sizes (the same as Western boxes) are as follows:

200—2¼", 160—2½", 112—2¾", 96—3", 48—3" (½ bushel), 72—3¼" or 48—3½" for apples packed either cheek up or stem up.

We are sales agent for one of the largest, oldest and most reliable carton manufacturers in the East. We know you will be pleased with this beautiful and sturdy carton.

"Get our prices before placing your order for any apple containers. You will be amazed at the low prices which we are quoting for this handsome shipping container. The prices are practically the same as the new low prices at which baskets are sold this season."

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